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AERONAUTICS BULLETIN : NUMBER FIVE

UNIVERSITY OF ILLINOIS
THE INSTITUTE OF AVIATION
URBANA, ILLINOIS

Evaluation of the School Link As an Aid in Primary Flight Instruction

By

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UNIVERSITY OF ILLINOIS BULLETIN

VOLUME 46; NUMBER 71; JUNE, 1949. Published seven times each month by the University of Illinois. Entered as second-class matter December 11, 1912, at the post office at Urbana, Illinois, under the Act of August 24, 1912. Office of Publication, 358 Administration Building, Urbana, Illinois.

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2500—4-49—41033

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Evaluation of the School Link As an Aid in Primary Flight Instruction

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PUBLISHED BY THE UNIVERSITY OF ILLINOIS, URBANA
1949

FOREWORD

THIS MONOGRAPH is the fifth in a series of bulletins on aviation subjects which is being issued from time to time by our Institute of Aviation. It reports the significant results of two experiments in the evaluation of a synthetic training aid — the School Link.

Both authors are trained in psychology and are certificated pilots. Dr. A. C. Williams holds an appointment as Research Assistant Professor of Psychology in the College of Liberal Arts and Sciences. During World War II he served as a Naval aviator. Mr. Ralph E. Flexman has been a flight instructor in the Institute of Aviation since it was established in 1945. He served in World War II as an Air Force flight instructor.

The writers wish to express their thanks and appreciation to those who have aided in the experiments: to Link Aviation, Inc., for furnishing the trainer and for the services of Mr. Paul E. Dittman of their staff who helped construct the training syllabi and made many helpful suggestions throughout the course of the study; to Mr. Jesse W. Stonecipher, Chief Flight Instructor, Institute of Aviation, who arranged for the subjects and the instructors to participate in the experiments, as well as for use of the aircraft; to the flight instructors — Mr. Delbert P. Shroyer, Mr. David H. Shroyer, Mr. Phillip Henderson, Mr. Willis C. Culberson, Mr. Scott G. Hasler, and Mr. Robert L. Ayers — who conscientiously performed their part in the project and helped set up the standards of flight tolerances which were used.

The Institute of Aviation is glad to make available the information contained in this monograph, which is the forerunner of a series of reports on experiments. In it, as in all publications of the Institute, the authors have been given complete freedom to express any opinions they may wish with the understanding that they take sole responsibility therefor.

LESLIE A. BRYAN,
Director

May, 1949

INTRODUCTION

Many devices which do not leave the ground have been built to simulate the flight of aircraft. Some simulate contact flight; others, instrument flight; while still others simulate a specific aspect of flight such as taxiing, navigation, pursuit gunnery, and so on. The purpose of all these devices is to train flight personnel. It is believed that if training can be accomplished by such means on the ground, a great saving in time, money, and lives will be realized. However, in order for any of these trainers to be effective, a transfer of training from the device to the function it simulates must occur. The skills learned in the trainer must carry over and apply to performance in the actual situation.

Strangely enough, although transfer of training is the lifeblood of a training device, very little effort has been made to determine whether or not transfer actually occurs, or, if it does, to what extent it occurs. Trainers have been used for years without anyone knowing, except as a matter of opinion, whether or not the devices were effective in training personnel for performance on the actual operational task which they were designed to simulate. It was naturally assumed that if the trainer accurately reproduced the functions of the pertinent characteristics of the aircraft, and if the task of operating the trainer were analagous to the task of operating the aircraft, transfer of training could not help but occur, and, therefore, the trainer could be said to be valid. Validity of this sort is known as face validity. Face validity is based on the *obviousness* of the analogy between the operation of the trainer and the operational task itself and is largely a matter of opinion. Face validity may or may not be dependable.

A more certain estimate of the validity of a training device can be obtained by actually measuring the extent to which skills learned in the trainer transfer to the performance of the real task. There are a variety of techniques for obtaining these measurements, but most of them are based on a technique whereby two groups of subjects, one of which has received instruction in the training device, are contrasted in their ability to learn the operational task. The group receiving instruction in the training device is known as the Transfer Group; the other group is known as the Control Group. If the device is an effective trainer, it would be expected that the Transfer Group would outperform the Control Group in learning the operational task. If this is the case, then positive transfer is said to occur. If there is no difference between the groups in their ability to learn the operational task, it

is then evident that the special training received by the members of the Transfer Group has not helped them and that no transfer has occurred. It is also possible, and not infrequently true, that instruction in the training device interferes with learning the operational task. In such a case, the Control Group would outperform the Transfer Group. This is known as negative transfer.

The amount of transfer, whether positive or negative, is usually expressed as a per cent of the total learning which is possible, thus:

$$\% \text{ transfer} = \frac{C-T}{C-X} \times 100$$

"C" equals the Control Group learning score, "T" equals the Transfer Group learning score, and X represents the total possible learning score on the operational task. This equation takes different forms, depending upon the kind of learning score obtained and whether or not relative or absolute transfer is to be computed. In the form given, learning must be measured in terms of savings, such as number of air trials.

This bulletin is a report of two transfer of training experiments which were conducted with a contact ground trainer known as the School Link. The experiments were conducted at the University of Illinois Airport, the first one during the fall semester, 1947-48, the second during the spring semester, 1948. The purpose of the experiments was to discover to what extent skills learned in the trainer transferred to the task of learning to fly a light aircraft.

The trainer, which was provided by Link Aviation, Inc., for the experiments, was designed primarily as a classroom demonstrator and not as a flight trainer. However, it was believed that its performance was sufficiently realistic to warrant its evaluation as a preflight trainer.

The trainer, which is mounted on a pedestal, consists of an open cockpit with wings and a tail group attached. It is free to pitch, yaw, bank, and turn. These movements are accomplished by the manipulation of conventional aircraft controls within the cockpit. The trainer used was surrounded for 270 degrees by a circular screen eleven feet high placed seven feet from the cockpit. This screen was made of white cloth and was unmarked except for a black horizontal line representing the horizon and two reference marks which, when viewed from the cockpit, served as a guide to normal climb and normal glide attitudes. There were also marks on it indicating cardinal compass directions.

The trainer possesses many of the characteristics of an aircraft, including dynamic stability, negative yaw, loss of lift resulting in nose heaviness during turns, change in pitch attitude as a result of change in power, overbanking tendency, and "live" feel to the controls. Operative light aircraft instruments are included, together with throttle, elevator trim tab, ignition switch, carburetor heat, fuel shut-off valve, and so forth, for the purpose of learning cockpit procedure. Also, to make the flight situation more realistic, the effects of turbulent air can be simulated.

The manufacturers of the trainer believed that a great deal of what is learned in the normal course of primary flight instruction could be learned in the School Link and that, as a result, preflight training in the trainer could be substituted for part of the time spent in the air, or, if direct substitution were not possible, at least instruction in the trainer would facilitate training in the air. Accordingly, as a practical example of trainer use, an experiment was designed to determine whether or not preflight instruction in the School Link would reduce the number of hours of dual flight instruction normally required before solo in a real aircraft.

THE FIRST EXPERIMENT

Method and Procedure

Forty-eight of the students enrolled in the primary flight training course offered by the University were selected on a voluntary basis for the experiment. None had had previous flight experience as a pilot or as a regular member of a flight crew. The students were divided into three equal groups. Group A, the Control Group, received no preflight instruction in the School Link; Group B received two hours of preflight instruction in the School Link; and Group C received four hours of preflight instruction in the School Link. The students were assigned to four experienced flight instructors. Each instructor received twelve students, four from each group.

The design called for a separate group of instructors to give the preflight training in the Link. At the end of this training the students were turned over to their flight instructors. These instructors were unaware of the Link history of their individual students, except that they knew they had four from each of the three groups. Their task was to train the students according to the ordinary flight training

syllabus, and to move each as fast as he was able to progress. These flight instructors were permitted to solo a student whenever they felt the student was ready, regardless of the amount of instruction that had been given. Special permission from the Civil Aeronautics Administration was obtained for this purpose.

If preflight training in the Link were effective, it would be expected that those who had received it would solo after fewer hours of flight instruction than those who had not received it. Furthermore, if the amount of Link instruction were a factor, some difference in time to solo between the two-hour group and the four-hour group would occur.

The syllabus for the training offered in the Link was based on the regular flight syllabus which had been adapted for the trainer by Mr. Paul Dittman of Link Aviation, Inc. It consisted of the usual exercises on effect of controls, straight and level flight, turns, climbs, glides, stalls, and traffic pattern, but no take-offs or landings, since the Link does not simulate these maneuvers. Both the two-hour and the four-hour group practiced the same exercises, the four-hour group in eight half-hour periods, the two-hour group in eight quarter-hour periods. A more detailed description of the Link and the flight syllabus is not pertinent to the results and, therefore, will not be included.

Results

When all of the students had soloed, an analysis of the number of hours of dual flight instruction necessary before solo showed that there was no real difference between groups in this respect. Those who had received preflight training in the School Link took as many flying hours before solo as did those who had not received such training. Similarly, there was no difference between the two-hour and the four-hour groups in time to solo. The times to solo required by all students are shown in Table 1. They are arranged according to group and instructor and given in hours and tenths of hours.

Arranged in this way, the data form twelve subgroups of four students each. An analysis of variance using within-group variance as the estimate of error, shows that the difference between the means of the zero-hour, two-hour, and four-hour groups is no greater than would be expected by chance. On the other hand, the difference between the means of the instructor groups is greater than would be expected by chance, being significant at the 1 per cent level. Evidently, the instructor was a significant source of variation in time to solo (as might be expected from other studies) in that his differential influence was great enough to dominate individual differences in student ability.

TABLE 1. Number of Hours of Dual Flight Instruction Before Solo

	Zero-Hour Link	*Two-Hour Link*	*Four-Hour Link*	
Instructor	6.3	6.5	8.7	
A	5.5	6.3	8.1	Total = 72.7
	5.8	6.7	3.6	
	5.8	4.9	4.5	Mean = 6.06
Instructor	4.0	3.7	5.0	
B	5.0	5.8	2.5	Total = 54.6
	4.0	5.0	5.5	
	4.1	5.0	5.0	Mean = 4.55
Instructor	5.0	6.0	4.3	
C	4.1	5.0	4.0	Total = 52.8
	2.5	3.0	4.2	
	6.9	3.8	4.0	Mean = 4.40
Instructor	11.0	4.7	5.0	
D	8.0	5.7	4.2	Total = 73.2
	6.3	8.3	3.9	
	4.0	8.0	4.1	Mean = 6.10
Total	= 88.3	= 88.4	= 76.6	= 253.3
Mean	= 5.52	= 5.53	= 4.79	= 5.28

Discussion of Results

Since transfer of training as measured by time to solo evidently did not occur in this group of students, it is well to ask why it did not. It could be either that nothing which was applicable to flight was learned in the trainer, or that what was learned was applicable but did not affect the particular criterion used. It was the assumption of most of those connected with the experiment that the Control Group, those with zero-hours Link, would solo in close to the standard time of eight hours. Consequently, it was believed that the Link students had the opportunity to save a maximum of about 5.5 hours, allowing an average of two and a half hours for landing practice and spins which could not be learned in the Link. The fact that for non-Link students the average time to solo was 5.5 hours, well below eight hours, reduced the total possible savings which could be achieved by the Link group to about 2.5 hours. Also, the fact that the instructors were unaware of which students had had Link training made it necessary for *all* students to take some time to demonstrate their ability to do

airwork. Consequently, the total possible savings were reduced still further.

After the first hour of dual instruction the instructors could identify their Link students with fair accuracy, although they were not informed about the correctness of their identifications. According to the instructors, this identification was based on the superior initial performance of members of the Link group. If the Link group was in fact superior during the first few hours, this advantage was lost by the time the students soloed. It may be either that proficiency in airwork beyond a certain easily attained minimum is unimportant as a criterion for solo, or that the flight syllabus is so unexacting that the non-Link students were able to make up their initial deficiency on airwork during landing practice.

In any event, it was decided that the experiment was not conclusive either way. The criterion used was so heavily weighted in landing and take-off performance, which the Link does not teach, that any transfer which might have occurred was overshadowed. Accordingly, a second experiment was planned in which only performance in airwork would would be measured, since it was believed that any transfer would have to occur in this area.

THE SECOND EXPERIMENT

Method and Procedure

The second experiment was different from the first in design and procedure. As a measure of learning, it was decided to use a conventional method of recording the number of trials required to reach a given standard of proficiency. Eight airwork exercises were constructed and arranged in what was designed to be a logical progression from effect of controls to flying the traffic pattern.

In order, these exercises were as follows:

1. Effect of controls
2. Return to level flight
3. Climbs and glides
4. Level 180 degree turns to a point
5. Alternate 180 degree climbing and gliding turns
6. Stalls, normal and complete, power-on and power-off
7. Entry into traffic pattern
8. Flying in the traffic pattern

Each exercise was broken down into a number of items on which the student was checked as having either passed or failed. As an example, Exercise 4, "Level 180 Degree Turns to a Point," consisted of the following items:

Entry

a. Look to right and left
b. Aileron and rudder — coordination
c. Constant 30 degree bank ± 5 degrees
d. Nose level

Recovery

e. Aileron and rudder — coordination
f. Directional control ± 10 degrees
g. Altitude constant ± 50 feet
h. Nose level
i. Wings level

The student's performance was checked — passed or failed — on each item of the exercise as it occurred. A failure on any item was considered an error. A trial was considered one performance of the complete exercise. The criterion of learning for the exercise was the performance of three consecutive errorless trials. The amount of learning was measured by the number of trials required prior to reaching the criterion. The student was required to repeat the exercise until the criterion was reached.

After the first trial, if the student appeared not to understand the exercise at all, the instructor gave one demonstration. Thereafter, he gave demonstrations from time to time if he felt they were essential to the student's understanding of the maneuver. Demonstrations were kept to a minimum, and a record of them was kept. During a trial, no word was spoken by the instructor until the student made an error. The instructor could point out the error either at that time or at the end of the trial. The instructor reviewed each trial in which an error was made, pointing out what errors were made and what was done correctly and suggesting ways to correct the error on the next trial. If an errorless trial was accomplished, the instructor said nothing.

This procedure placed great reliance on the judgment of the instructor. He was responsible for deciding if the performance were satisfactory or unsatisfactory on each item. These judgments ultimately determined the number of trials taken by a student. In order to obtain some degree of standardization, the four instructors used in

the experiment participated in the construction of the exercises, and themselves set up the standards to be used as criteria. By means of conferences and mutual demonstrations in the Link and in the air, tolerances in meeting the criterion for each item were established. Scoring forms for all exercises were made up, and instructors practiced rating each other in the air and in the Link. Four extra subjects were obtained to pretest the procedure and to give the instructors added practice in the new methods of instruction and scoring. These subjects were trained to criterion in each exercise, first in the Link and then in the air. As a result of this experience, several changes were made in the exercises and tolerances used.

In spite of these efforts to achieve standardization, it was not expected that the instructor would be eliminated as a variable in the experiment nor that the scoring system used would be uninfluenced by instructor differences. An estimate of scoring reliability was obtained by having combinations of two instructors simultaneously and independently score the performance of a third, both in the Link and in the air. Unfortunately, the short time available before the new semester started and poor flying weather prevented a systematic study of reliability by this promising method. The few data obtained this way showed satisfactory reliability for the scoring procedure, but the question of variation between instructors was left to be handled by the design of the main experiment itself.

Experimental Design

Forty-eight students without previous flight training were divided at random into two groups of twenty-four each. One of these groups, the Control Group, received training only in the air. The other group, the Transfer Group, received training both in the Link and in the air. The students were assigned at random to four instructors — twelve students to an instructor. Half of each instructor's students were from the Control Group; the other half were from the Transfer Group.

The Transfer Group received both their Link training and their flight training concomitantly from the same instructor. They were trained to criterion in Exercise 1 in the Link and then trained to criterion in the same exercise in the air. The same procedure was used with the other exercises in turn. In case proficiency was reached on an exercise in the Link before the end of a Link period, practice on the next exercise was started, but training in the air never preceded training in the Link. Thus, a student always reached the criterion pro-

ficiency of three consecutive errorless trials on an exercise in the Link before starting the exercise in the air.

This procedure resulted in three different sets of scores designated as LL (Link-Link), LA (Link-Air), and CA (Control-Air). The first set consisted of the number of trials required by the Transfer Group to reach criterion in the Link. The second consisted of the number of trials taken by the Transfer Group to reach criterion in the air. The third consisted of the number of trials taken by the Control Group to reach criterion in the air.

The design was such that the total variation in the number of trials required to reach proficiency could be analyzed, and portions assigned to various sources. The source of primary interest was the fact that half of the students had Link training and the other half did not. If this constituted a significant source of variation in the number of air trials, and if the resulting difference between groups were in favor of Link-trained students, then positive transfer of training could be said to have occurred. Other pertinent sources of variation were the students themselves, the exercises, the instructors, and various first order interactions between these variables.

If the analysis of variance should show evidence of transfer, then the amount of transfer could be computed for any exercise or group of students from the following formula:

$$\%\text{ transfer} = \frac{\text{Control Group score} - \text{Transfer Group score}}{\text{Control Group score} - \text{total possible score}} \times 100$$

In this case, the total possible score equalled zero trials, indicating that the limit of learning was perfect performance on the first three trials (the criterion measure). By computing per cent transfer for each exercise, the relative effectiveness of the Link in training for different maneuvers could be studied, and data obtained which might be useful in designing a practical training syllabus for Link use.

In addition to per cent transfer, a second coefficient, called an efficiency ratio, was developed. The efficiency ratio represents the number of air trials saved per Link trial spent, and is an indication of the economy of the Link in accomplishing whatever transfer may have occurred. The ratio is stated by the relationship $\frac{CA - LA}{LL}$. The numerator CA — LA represents the savings in air trials of the Transfer Group over the Control Group, and the denominator LL represents

the cost of the savings in terms of the number of Link trials taken by the Transfer Group.

In addition to these ratios, estimates of transfer of training could be obtained from the frequency of errors within each exercise. Since each exercise consisted of a number of separate items on which the students were checked, the number of errors made on each item by various students or groups of students could be computed. If Link training were effective, it would be expected that the Transfer Group would make fewer errors in the air than would the Control Group. Transfer measures based on errors could be computed for each item of an exercise, or for the exercise as a whole. In the former case, information should be obtained which would be valuable in evaluating the flight characteristics of the trainer itself, since the items are relevant to the kind of performance obtainable from the Link. In the latter case, the transfer measures obtained could be compared directly with those based on trials.

In the case of all transfer measures, it becomes necessary to decide if they indicate significant positive transfer, no transfer, or significant negative transfer. In general, a high positive or negative per cent transfer, when based upon a sufficient number of trials or errors, can be considered significant. However, the significance of low percentages, or high percentages based on a few cases, is uncertain unless there is some way of evaluating them. A low per cent transfer, either positive or negative, which is not significant is equivalent, of course, to no transfer at all. In order to determine the significance of the per cent transfers obtained, and at the same time establish clear and reasonable definitions of positive transfer, no transfer, and negative transfer, each difference in trials or errors between Transfer Group and Control Group was tested for significance by the χ^2 method. It was arbitrarily decided that differences in frequency of trials or errors in favor of the Transfer Group at the 1 per cent level of significance or greater would be considered positive transfer; differences not significant at the 1 per cent level would be considered to indicate no transfer; and differences in favor of the Control Group significant at the 1 per cent level or greater would be considered negative transfer.

Results

The number of trials to reach criterion proficiency required by each subject in each exercise according to Link status and instructor is shown in Appendix B. A summary of these data is shown in Table 2. Here it is evident that Transfer Group students required 368 fewer

TABLE 2. Distribution of Total Trials for Subgroups of Six Students Classified According to Link Status, Instructor, and Exercise

	Link-Link Instructor					*Link-Air* Instructor					*Control-Air* Instructor				
Exercises	I	II	III	IV	Total	I	II	III	IV	Total	I	II	III	IV	Total
1........	2	1	11	0	14	0	2	2	2	6	4	2	8	4	18
2........	28	41	29	14	112	35	55	37	10	137	42	40	42	28	152
3........	44	23	74	41	182	37	57	57	29	180	54	45	69	37	205
4........	70	70	123	69	332	42	62	116	39	259	38	66	141	55	300
5........	61	55	69	71	256	19	57	31	34	141	28	38	54	57	177
6a.......	17	18	13	8	56	53	43	38	34	168	46	42	75	58	221
6b.......	19	10	21	7	57	27	15	16	21	79	16	29	47	33	125
6c.......	23	29	29	18	99	64	61	68	37	230	80	102	58	63	303
6d.......	24	9	20	11	64	26	16	18	9	69	38	7	20	6	71
7........	19	19	30	25	93	11	21	10	5	47	6	15	24	24	69
8........	6	13	27	25	71	14	26	6	21	67	17	24	29	40	110
Totals.....	313	288	446	289	1336	328	415	399	241	1383	369	410	567	405	1751

air trials than the Control Group students. This is a significant difference at the 1 per cent level of confidence. An analysis of the variance of the Link-Air and Control-Air trials gave the results shown in Table 3. As an estimate of error, the variance of three first order and second order interactions were pooled, giving a mean square variance of 13.93 for 440 degrees of freedom. When compared with this, all sources of variation listed in the table proved significant. It can be said then, that the number of trials required in any instance is determined by the student himself, whether or not he has had Link training, his instructor, and, of course, the particular exercise being done. Among these, the subject seems to be least important, since the others are significant even when compared with subject variation. Since Link training proved to be a significant factor in the number of trials taken, and since the effect of the Link training was to reduce the number of air trials taken, it can be safely assumed that positive transfer of training did occur in this experiment.

An analysis of trials according to exercise is the first step in tracing the source of transfer. Table 4 shows three coefficients of transfer for each exercise. First is listed the per cent transfer based on trials, next the per cent transfer based on errors, and finally, the efficiency ratio or number of air trials saved per Link trial spent. Those per cent transfers which proved to be significant are starred (*).

Table 3. Results of Analysis of Variance of Link-Air and Control-Air Trials

Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Estimate of Variance*	
Link-Air — Control-Air	1	256.48	256.48*	
Instructors	3	465.28	155.09*	
Exercises	10	6134.02	613.40*	
Students	40	1229.30	30.73*	
Link × Instructors	3	174.02	58.01*	
Instructors × Exercises	30	2009.01	66.97*	
Link × Exercises	10	88.56	8.86[1]	ERROR
Students × Exercises	400	5591.70	13.98[1]	ERROR
Link × Instructors × Exercises	30	449.44	14.98[1]	ERROR

* The estimates of variance which are starred are significant at the 1 per cent level when compared with the pooled estimate of error variance.

[1] Constitutes the pooled estimate of error variance.

Table 4 shows that roughly 25 per cent (22 per cent trials, 28 per cent errors), or one quarter, of their flight training was accomplished by the Transfer Group students in the Link. In accomplishing this saving, one trial in the Link was worth .29 trials in the air. Exercises did not contribute equally to the over-all transfer. In terms of trials, only four out of a possible eleven exercises showed significant positive transfer, although the others were all in the direction of positive transfer. In terms of errors all but one exercise showed significant positive transfer. The discrepancy between the results for trials and errors will be discussed later, but in general these differences in significance occurred because there were many more errors than there were trials. With the exception of Exercise 1, no exercise was outstanding in its contribution to transfer. On the other hand, except for Exercise 6d, the Link was successful in saving a moderate amount of flight training in all maneuvers either in terms of trials or errors. These results do not suggest any special uses for the School Link within the scope of maneuvers employed in the experiment. The greatest saving was made in the case of Exercise 1. However, this exercise was not difficult for students to master even without Link training so that although the savings were relatively great, they are of little practical significance.

If the maneuvers are broken down according to the items of which they are composed, it is possible to trace the source of transfer still farther. In all eight exercises (or eleven, when stalls are considered separately) there are over two hundred items on which students were

TABLE 4. Per Cent Transfer (Trials), Per Cent Transfer (Errors), and Efficiency Ratio According to Exercises

EXERCISES	*Per Cent Transfer (trials)*	*Per Cent Transfer (errors)*	*Efficiency Ratio* $\frac{CA-LA}{LL}$
1 Effect of controls	67	79*	.86
2 Return to level flight	10	15*	.13
3 Climbs and glides	12	31*	.14
4 Level 180 degree turns to a point	14	28*	.12
5 Alternate 180 degree climbing and gliding turns	20	40*	.14
6 Stalls, normal and complete, power-on and power-off			
6a Normal stalls, power-on	24*	31*	.95
6b Normal stalls, power-off	37*	27*	.81
6c Complete stall, power-on	24*	13*	.74
6d Complete stall, power-off	3	−17	.03
7 Entry into traffic pattern	32	42*	.24
8 Flying in the traffic pattern	39*	33*	.61
Total (all exercises)	22*	28*	.29

* Significant coefficient at 1 per cent level of confidence (not applicable to efficiency ratio).

scored for errors. On each of these items, therefore, a certain frequency of errors occurred. By comparing the frequency of errors made by the Link-Air group with the frequency made by the Control-Air group the per cent transfer of training could be computed for each item. Table 5 shows the per cent transfer based on errors. Just as in the case of Exercise 1, which showed large transfer of training but small absolute saving because of the ease of the exercise, the transfer of training obtained on each individual item must be evaluated in the light of the difficulty or importance of that item. In order to achieve savings of practical importance to flight training, the School Link must provide transfer of training on items in which many errors are normally made. The two hundred items in the present experiment

were not equally difficult. An estimate of their difficulty is provided by the frequency of errors made by the Control Group. Those items on which the Control Group students made the most errors are evidently the most difficult items to learn. They are the items which provide the Link with its best opportunity to achieve savings of practical significance.

Consequently, in Table 5 the items have been removed from their context within the exercises and listed instead according to order of their difficulty — from the most difficult to the least difficult. The items can be identified by their code numbers, the key to which is given in Appendix A. Also listed in the table are the total errors made on each item by the Link-Air group and by the Control-Air group, the latter being the basis on which the rank order was constructed. Finally, the per cent transfer for each item is shown. Those preceded by a minus sign indicate negative transfer. Per cent transfers based upon significant differences between Link-Air and Control-Air are starred.

Table 5 shows that significant positive transfer occurred in the case of only twenty-nine of the two hundred items on which students were scored for errors. Significant negative transfer occurred in the case of two items. On the remaining items, there was a reduction of errors in most cases in favor of the Link trained students; but either the reduction was not great enough, or the total number of errors made was not great enough for the difference between groups to be significant.

The important items of the table are, perhaps, the first quarter in order of difficulty. These are the items on which a training device should make its greatest contribution. Of these fifty items, positive transfer occurred in the case of sixteen and there were no instances of negative transfer. The savings achieved on these sixteen items were of respectable proportions ranging from 46 to 62 per cent. But items on which significant transfer did not occur are of greater interest. These items identify the major weaknesses of the trainer. They are the items on which transfer should occur if the effectiveness of the trainer is to be improved. An analysis of them, in an attempt to account for lack of transfer, shows that many tend to fall into clusters based on common elements. Thus, eight of them concern directional control with changes in power and airspeed. In controlling direction under these circumstances, the pilot must move the controls so as to compensate for the effect of torque. The fact that no torque effect was built into this trainer suggests a reason for lack of transfer on those items.

TABLE 5. Per Cent Transfer Based on Errors Listed According to Order of Difficulty of Items

Rank Order	*Code*	TOTAL ERRORS *Link-Air*	TOTAL ERRORS *Con-trol-Air*	*Per Cent Transfer*	*Rank Order*	*Code*	TOTAL ERRORS *Link-Air*	TOTAL ERRORS *Con-trol-Air*	*Per Cent Transfer*
1	4a	109	241	55*	34.5	6ll	46	62	26
2	6qq	133	170	21	37	2r	57	60	05
3	6rr	117	136	14	38	3c	48	59	18
4.5	3aa	48	104	54*	39	3l	37	55	32
4.5	4d	88	104	15	40.5	3x	45	54	17
6	3bb	64	94	31	40.5	5v	26	54	52*
7	6k	54	88	39*	42	5p	24	53	55*
8.5	6nn	78	87	10	44	3m	44	51	13
8.5	6oo	48	87	44*	44	3p	12	51	76*
10	3t	60	82	27	44	6pp	20	51	61*
12	3r	57	81	29	46	3q	27	50	46*
12	3ee	89	81	−10	47	5u	23	49	53*
12	6mm	89	81	−10	49	2b	38	48	20
14	5i	57	80	29	49	5s	32	48	33
15	3h	64	78	17	49	8f	30	48	37
16	4c	60	77	22	51	5r	38	47	19
17.5	3u	40	76	47*	52.5	3dd	25	46	45*
17.5	6h	40	76	47*	52.5	5g	24	46	48*
19.5	2n	52	75	30	54	6d	40	44	09
19.5	3gg	85	75	−13	56	3f	18	43	58*
21	3j	50	71	29	56	3cc	45	43	−04
22	5h	35	70	50*	56	5x	12	43	72*
23.5	3w	57	68	16	58.5	2o	46	42	−10
23.5	4b	52	68	24	58.5	5z	16	42	62*
26	2g	53	67	20	61	3g	15	41	63*
26	3ff	25	67	62*	61	5l	36	41	12
26	4e	41	67	39	61	8u	28	41	31
28.5	3k	61	66	07	63	5gg	28	40	30
28.5	3z	52	66	21	65	3d	16	39	58*
30.5	4f	64	64	0	65	6ee	30	39	23
30.5	6j	50	64	22	65	6i	27	39	31
32	5e	27	63	57*	68	5m	42	38	−10
34.5	3n	68	62	−09	68	5t	26	38	31
34.5	6f	33	62	46*	68	5aa	47	38	−24
34.5	6g	57	62	08	70	5y	22	37	41

* χ^2 is significant at 1 per cent level.

TABLE 5. Continued

		TOTAL ERRORS					TOTAL ERRORS		
Rank Order	*Code*	*Link-Air*	*Con-trol-Air*	*Per Cent Transfer*	*Rank Order*	*Code*	*Link-Air*	*Con-trol-Air*	*Per Cent Transfer*
72.5	3e	12	36	67*	106.5	7g	9	24	62*
72.5	5j	6	36	83*	106.5	8d	8	24	67
72.5	6bb	23	36	36	109.5	2f	16	23	30
72.5	6ss	19	36	47	109.5	2i	18	23	21
77	2d	30	35	14	109.5	2p	28	23	−21
77	2h	37	35	−05	109.5	3o	8	23	65*
77	3i	17	35	51	112.5	5c	23	22	−04
77	3s	15	35	57*	112.5	7a	15	22	31
77	5o	17	35	51	116.5	2c	17	21	19
81.5	2e	19	34	44	116.5	6i	27	21	−28
81.5	2k	42	34	−23	116.5	6l	11	21	48
81.5	3v	17	34	50	116.5	6kkk	20	21	05
81.5	5f	19	34	44	116.5	7b	18	21	14
85	2l	34	33	−03	116.5	8x	25	21	−19
85	3b	27	33	18	121.5	2q	28	20	−40
85	6e	17	33	48	121.5	5dd	14	20	30
87.5	4g	61	32	−90*	121.5	8g	8	20	60
87.5	5n	19	32	41	121.5	8v	14	20	30
89.5	5ff	26	31	16	125	4h	9	19	53
89.5	6b	19	31	38	125	6dd	12	19	36
91.5	5cc	20	29	31	125	6iii	2	19	89
91.5	6aa	21	29	27	129	5k	7	18	61
94	5ee	15	28	46	129	6y	16	18	11
94	7d	10	28	64*	129	6ii	26	18	−44
94	7e	18	28	35	129	6kk	36	18	−105
98.5	2m	12	27	55	129	8y	15	18	17
98.5	3a	15	27	44	132.5	6a	12	17	29
98.5	3y	14	27	48	132.5	6v	5	17	70
98.5	5w	18	27	33	132.5	5a	10	16	38
98.5	6x	17	27	37	135.5	5hh	6	16	62
98.5	8w	20	27	26	135.5	8c	6	16	62
102.5	2a	26	26	0	135.5	8l	7	16	56
102.5	7c	17	26	35	138.5	5q	4	15	73
104.5	5d	23	25	08	138.5	6p	7	15	53
104.5	5ii	13	25	48	141	5bb	2	14	86

TABLE 5. Concluded

Rank Order	Code	Total Errors: Link-Air	Total Errors: Con-trol-Air	Per Cent Transfer	Rank Order	Code	Total Errors: Link-Air	Total Errors: Con-trol-Air	Per Cent Transfer
141	6cc	12	14	14	169	6lll	7	7	0
141	8m	7	14	50	172.5	1b	2	6	67
145	2j	7	13	46	172.5	6u	7	6	−17
145	8e	11	13	15	177	1h	0	5	100
145	8h	6	13	53	177	6zz	3	5	40
145	8n	5	13	61	177	6ggg	6	5	−20
145	8t	10	13	23	177	6mmm	1	5	80
149	6c	9	12	25	177	8k	3	5	40
149	7f	7	12	42	177	8p	1	5	80
149	8j	9	12	25	182.5	1f	1	4	75
151.5	5b	3	11	72	182.5	1g	1	4	75
151.5	6fff	8	11	27	182.5	6aaa	5	4	−25
154.5	6ff	3	10	70	182.5	6eee	9	4	−125
154.5	6gg	7	10	30	188	1d	2	3	33
154.5	6hhh	21	10	−110	188	6q	3	3	0
154.5	8z	15	10	−50	188	6xx	8	3	−167
158	1c	1	9	89	188	6bbb	6	3	−100
158	6z	6	9	33	188	6ddd	6	3	−100
158	6hh	4	9	56	188	6jjj	2	3	33
163	6m	5	8	38	188	8s	3	3	0
163	6jj	36	8	−350*	193.5	1e	0	2	100
163	6ccc	5	8	38	193.5	6w	2	2	0
163	8b	7	8	12	193.5	6tt	3	2	−50
163	8o	7	8	12	193.5	8a	4	2	−100
163	8q	9	8	−12	198	1a	0	0	0
163	8r	6	8	25	198	6n	0	0	0
169	8o	7	7	0	198	6uu	0	0	0
169	6s	10	7	−42	198	6vv	4	0	−00
169	6t	5	7	28	198	6yy	4	0	−00
169	6ww	7	7	0					

A second group of six items is associated with the characteristics of a power-on stall, particularly the power-on complete stall. The trainer does not stall in the same way as the aircraft. The stall is less violent, with much greater lateral and directional stability. Since the items where transfer failed to occur are concerned largely with directional and lateral stability in this maneuver, the explanation for

lack of transfer is fairly evident. The results indicate that the stall characteristics of the trainer should be improved; specifically, the trainer should be made directionally and laterally unstable during the stall.

Similarly, other item clusters suggest that the ball-bank mechanism should be improved, not with respect to its readings during entry into a turn, but rather on the recovery to level flight from a turn. On recovery from a turn, a different use of rudder and aileron to keep the ball centered is required in the trainer than in the aircraft, whereas on an entry into a turn there is high positive transfer. In like manner, transfer did not occur on items which required use of the altimeter to achieve or maintain a given altitude performance. The altimeter used in the trainer did not display the customary "lag" found in altimeters in aircraft. This fact may have been responsible for lack of transfer.

The preceding examples are cited only to illustrate the way in which these data may be used to identify trainer characteristics which need improvement. Whether or not the modifications indicated would result in improved transfer on those items is still a matter for speculation. Until such changes are made and evaluated, there is no sure answer. All that can be said is that these results do show which items of an airwork syllabus are difficult and, therefore, important, and on which of these the trainer is effective in achieving transfer. Examination of those items on which the School Link failed suggests discrepancies between trainer performance and actual aircraft performance which might be responsible for lack of transfer.

Discussion and Conclusions

It is evident from these results that those students who received Link training were aided by it in learning to fly. Link training substituted for approximately one quarter of the normal amount of flight training as determined by the Control Group. The amount of overall transfer of training was greater when measured in terms of errors than in terms of trials. This may be accounted for by the hypothesis that repetition of errors on a single item within an exercise may unduly extend the number of trials, with the result that the number of trials becomes a less representative index of learning than the number of errors. It does suggest that the most economical use of the Link should be based on errors made rather than on whole trials. Instruction should be aimed at eliminating errors without requiring performance of complete trials in the process.

In attempting to trace the source of the over-all transfer, the results indicate that each exercise contributes a relatively small amount

to the total. In terms of trials, only four of the eleven exercises show significant positive transfer. The other seven all have positive coefficients, but either they are not large enough or the number of trials on which they are based is not large enough to reach significance. This indicates that the significant over-all transfer derives from an accumulation of small amounts of transfer, themselves not significant, in each exercise. In terms of errors, the same interpretation may be advanced with the difference that here all exercises except one are themselves significant. The highest per cent transfers — 79%, 42%, and 40% — are found in Exercises 1, 7, and 5, respectively. These, however, are not the most important exercises in terms of number of errors made. The Link's greatest contribution, therefore, occurred among the easier exercises. Had it occurred on the most difficult exercises, the over-all amount of transfer would have been greater.

Tracing the source of transfer still further to the items within each exercise, the results are similar. Among the items found to be the most difficult, only a small proportion showed significant positive transfer. The total over-all transfer must come then from the accumulation of small savings from many items both difficult and easy. Included among the items were some with coefficients of negative transfer. All of these were unimportant — that is to say, easy — items which did not contribute greatly to the total. Analysis of those items where transfer did not occur shows promise of providing useful information for improving the characteristics of the trainer. By classifying items according to difficulty, it is possible to identify those which are of practical importance to training. These are also the items with respect to which most effort should be spent improving the trainer so as to increase transfer.

We may conclude that training in the School Link does not save any flight time prior to solo because readiness to solo does not depend upon the airwork skills taught in the trainer. A direct measure of airwork skills shows that a portion of them may be learned in the School Link. A breakdown of these skills into their component parts shows that, in general, Link training results in small savings throughout, the accumulation of which results in a significant over-all transfer of training of about 25 per cent. In a small proportion of cases Link training resulted in significant savings on the parts themselves. Analysis of some of the remaining components can yield information which suggests ways of modifying the trainer in order to increase transfer of training.

APPENDIX A

This appendix contains a breakdown and description of the exercises according to items on which subjects were checked. The items are coded for identification in the text. Notes elaborating on tolerances used in checking the less obvious items are included.

The student's proficiency in performing each of the eight exercises both in the Link and in the air was recorded on check sheets on which the maneuver or maneuvers were broken down into their component parts. It was thought that if an exercise were minutely analyzed and the pilot's performance on its parts recorded, there would be less variability in instructor judgment on the student's over-all performance of an exercise, not in relation to a grade but according to whether or not a trial was satisfactorily accomplished.

The tolerances on the attitude and directional control of the aircraft were associated with certain agreed-upon reference points on the aircraft itself. For recording the wings as being level, the wings were to be in a bank of not more than eight degrees. An eight degree bank was attained if the wing tip appeared to touch the horizon. The airplane was said to be in level flight longitudinally if the angle formed by the underside of the wing and the horizon did not exceed five degrees. Directional variance was measured by the angle formed by the longitudinal axis of the aircraft and a section line. The aircraft was recorded as flying straight if this angle did not exceed ten degrees. Where judgments concerning the coordinated use of aileron and rudder were required, a more definite tolerance measure — whether or not the ball from a turn and bank indicator was displaced more than its own diameter — was used.

In Exercise 1, each of the eight adjustments was considered satisfactory if the first response to the verbal order to make the adjustment was in the correct direction. Extent of movement was not considered.

In Exercise 2, each of the adjustments had a time limit of ten seconds. The instructor would put the airplane in a certain attitude and then tell the student to return the airplane to straight and level flight. At the end of a ten second period the instructor recorded whether or not the airplane was in straight and level flight.

In Exercise 3, throttle coordination in the climb entry was determined by whether or not the power was increased as the angle of attack was increased and whether or not full throttle had been applied by the time a normal climb attitude was established. In returning from a climb to straight and level flight, the throttle was *not* to be retarded until the airplane had been back to straight and level flight for at least three seconds. In the glide entry, the carburetor heat control was to be in the full *on* position before the throttle was retarded. The "attitude held" in the glide entry referred to how straight and level the airplane remained while the cruising airspeed was dissipated to that for a normal glide. Throttle coordination in the recovery from a glide was determined by whether or not the power was increased as the nose of the airplane came back to level flight.

In Exercise 4, the student was required to look to the right and to the left prior to each turn. This was considered to be just as important as any

of the other elements in the turn exercise. The standard for a thirty degree bank required that the wing strut appear to be parallel to the ground. The tolerance was approximately five degrees on either side of the standard attitude.

In Exercise 5, the rate of turn judgment was largely a matter of instructor standardization. The degree of bank in the climbing turn was required to be plus or minus five degrees from a standard attitude. This standard attitude occurred when the wing tip appeared to be just on the horizon. The carburetor heat was to be applied within ten degrees either side of the forty-five degree point. The recovery to straight and level flight was to be started twenty degrees before the desired direction with a ten degree tolerance on either side. The nose attitude in the glide was that required for a sixty mile per hour glide, with an allowable tolerance of five miles per hour on either side.

In Exercise 6, the nose attitude for the power-on stalls was an angle of approximately forty-five degrees. The standard from which this angle was judged was the angle formed by the horizon and the underside of the wing tip. The maximum variation allowable for this attitude was about plus or minus ten degrees. For the power-off stalls, the student was expected to use the same procedure for entering a glide as in Exercise 5, and then from this attitude to enter the stall.

Exercises 7 and 8 were procedural type exercises for which the various adjustments were based upon a temporal factor. In Exercise 7, the student was to establish an entry leg to the traffic pattern that was at least one mile in length, at a forty-five degree angle to the downwind leg of the pattern; maintain an altitude of eight hundred feet plus or minus one hundred feet; look carefully for other traffic; and intersect the downwind leg somewhere in the middle third. In Exercise 8, the student was given control of the airplane right after take-off, at which time recording of the exercise began.

CODE	DESCRIPTION
	EXERCISE 1—EFFECT OF CONTROLS
1a	Nose up
b	Right wing down
c	Nose right
d	Add power
e	Nose down
f	Left wing down
g	Nose left
h	Decrease power
	EXERCISE 2—RETURN TO LEVEL FLIGHT
	From nose high attitude
2a	Nose level
b	Directional control
c	Wings level
	From left wing low attitude
d	Nose level
e	Directional control
f	Wings level
g	Aileron and rudder—co-ordination
	From nose low attitude
h	Nose level
i	Directional control
j	Wings level
	From climbing turns
k	Nose level
l	Directional control
m	Wings level
n	Aileron and rudder—co-ordination

CODE	DESCRIPTION
	From diving turn
o	Nose level
p	Directional control
q	Wings level
r	Aileron and rudder—co-ordination
	EXERCISE 3—CLIMBS AND GLIDES
	Climb entry
3a	Wings level
b	Climb attitude
c	Directional control
d	Throttle—amount
e	Throttle—coordination
	Maintaining climb for 300 feet
f	Wings level
g	Climb attitude
h	Directional control
	Recovery
i	Wings level
j	Nose level
k	Directional control
l	Throttle—amount
m	Throttle—coordination
n	Recover ±50 feet
	Glide entry
o	Carburetor heat on
p	Throttle—amount
q	Throttle—smoothness
r	Nose level
s	Wings level
t	Directional control
u	Glide attitude established
v	Wings level
w	Directional control
	Maintain for 300 feet
x	Glide attitude held
y	Wings level
z	Directional control
	Recovery
aa	Throttle—amount
bb	Throttle—coordination
cc	Nose level
dd	Wings level
ee	Directional control
ff	Carburetor heat off
gg	Recover ±50 feet

CODE	DESCRIPTION
	EXERCISE 4—LEVEL 180 DEGREE TURNS TO A POINT
	Entry
4a	Look to right and left
b	Aileron and rudder—co-ordination
c	Constant 30 degree bank ±5 degrees
d	Nose level
	Recovery
e	Aileron and rudder—co-ordination
f	Directional control ±10 degrees
g	Altitude constant ±50 feet
h	Nose level
i	Wings level
	EXERCISE 5—ALTERNATE 180 DEGREE CLIMBING AND GLIDING TURNS
	Entry to right climbing turn
5a	Coordinated use of throttle
b	Coordinated use of elevator
c	Coordinated use of aileron
d	Coordinated use of rudder
e	Constant rate of turn
f	Climb attitude established
g	Climb attitude held
h	Degree bank established
i	Degree bank held
	Recovery to gliding turn
j	Carburetor heat on at 45 degree point
k	Start recovery at 20 degree point
l	Coordinated use of throttle
m	Coordinated use of elevator
n	Coordinated use of aileron
o	Coordinated use of rudder
	At level flight point
p	Directional control
q	Wings level
r	Nose level
	Gliding turn, left entry
s	Coordinated use of throttle
t	Coordinated use of elevator
u	Coordinated use of aileron
v	Coordinated use of rudder

CODE	DESCRIPTION
w	Constant rate of turn
x	Glide attitude established
y	Glide attitude held
z	Degree bank established
aa	Degree bank held
	Glide recovery
bb	Start recovery at 20 degree point
cc	Coordinated use of throttle
dd	Coordinated use of elevator
ee	Coordinated use of aileron
ff	Coordinated use of rudder
gg	Directional change at level flight point
hh	Wings level at level flight point
ii	Nose level at level flight point

EXERCISE 6—STALLS, NORMAL AND COMPLETE, POWER-ON AND POWER-OFF

CODE	DESCRIPTION
	Normal stall, power-on
6a	Entry—stall attitude established
b	Entry—directional control
c	Entry—wings level
d	Maintaining—stall attitude
e	Maintaining—wings level
f	Maintaining—directional control
g	Recovery—start at break
h	Recovery—full throttle
i	Recovery—forward stick
j	Recovery—wings level
k	Recovery—directional control
l	Recovery—retard throttle
	Normal stall, power-off
m	Entry—carburetor heat on
n	Entry—retard throttle
o	Entry—nose level
p	Entry—directional control
q	Entry—wings level
r	Entry—glide attitude established
s	Entry—directional control
t	Entry—wings level
u	Entry—stall attitude established
v	Entry—directional control
w	Entry—wings level
x	Maintaining—stall attitude
y	Maintaining—directional control
z	Maintaining—wings level
aa	Recovery—start at break
bb	Recovery—full throttle
cc	Recovery—forward stick
dd	Recovery—wings level
ee	Recovery—directional control
ff	Recovery—retard throttle
gg	Recovery—carburetor heat off
	Complete stall, power-on
hh	Entry—stall attitude established
ii	Entry—directional control
jj	Entry—wings level
kk	Maintaining—stall attitude
ll	Maintaining—directional control
mm	Maintaining—wings level
nn	Recovery—start at horizon
oo	Recovery—full throttle
pp	Recovery—forward stick
qq	Recovery—directional control
rr	Recovery—wings level
ss	Recovery—retard throttle
	Complete stall, power-off
tt	Entry—carburetor heat on
uu	Entry—retard throttle
vv	Entry—nose level
ww	Entry—directional control
xx	Entry—wings level
yy	Entry—glide attitude established
zz	Entry—directional control
aaa	Entry—wings level
bbb	Entry—stall attitude established
ccc	Entry—directional control
ddd	Entry—wings level
eee	Maintaining—stall attitude
fff	Maintaining—directional control
ggg	Maintaining—wings level
hhh	Recovery—start at horizon
iii	Recovery—no throttle
jjj	Recovery—forward stick
kkk	Recovery—directional control
lll	Recovery—wings level
mmm	Recovery—add throttle

CODE	DESCRIPTION
	EXERCISE 7—ENTRY INTO TRAFFIC PATTERN
7a	Flight path 45 degrees to downwind leg
b	Intersection point correct
c	Altitude held ±100 feet
d	Check for traffic
e	Look to right and left
f	Path 180 degrees to runway
g	Altitude held ±100 feet
	EXERCISE 8—FLYING IN THE TRAFFIC PATTERN
	After take-off
8a	Maintain climbing attitude
b	Level off between 400-500 feet
c	Throttle and elevator co-ordination
	First turn
d	Look to right and left
e	Level turn ±100 feet
f	Proper crab
g	Start climb right after turn
h	Throttle and elevator co-ordination
	Second turn on downwind leg
i	Look to right and left
j	Start at 600 feet ±50 feet
k	Climbing turn
l	Attitude control
m	Level off at 800 feet ±100 feet
n	Throttle and elevator co-ordination
o	Directional control
p	Carburetor heat on
q	Opposite spot—establish glide
r	Throttle and elevator co-ordination
s	Directional control
t	Glide attitude held
u	First gliding turn—look to right and left
v	Maintain glide attitude
w	Establish crab
x	Clear engine
y	Second gliding turn—maintain glide attitude
z	Line up with runway

APPENDIX B

This appendix shows the number of trials to reach criterion proficiency required by each subject in each exercise according to Link status and instructor. Subjects are grouped according to instructor assignments.

LINK-LINK

	Instructor A						Instructor B					
Subject No.	1	2	3	4	5	6	7	8	9	10	11	12
Exercise 1....	1	0	0	0	1	0	1	0	0	0	0	0
2....	4	8	8	1	6	1	9	6	5	7	7	7
3....	6	10	13	8	5	2	3	3	2	10	4	1
4....	16	8	14	11	6	15	10	12	15	14	10	9
5....	8	7	23	9	6	8	3	8	6	16	14	8
6a...	1	2	4	3	3	4	9	1	1	2	2	3
6b...	1	3	4	8	1	2	4	1	2	0	1	2
6c....	2	3	3	5	6	4	7	6	6	4	0	6
6d...	2	7	5	7	2	1	1	0	1	4	1	2
7....	3	6	4	2	1	3	3	3	2	3	5	3
8....	0	3	1	1	0	1	0	4	3	1	2	3
	Instructor C						Instructor D					
Subject No.	13	14	15	16	17	18	19	20	21	22	23	24
Exercise 1....	2	0	4	2	2	1	0	0	0	0	0	0
2....	5	6	2	4	6	6	0	3	1	2	8	0
3....	6	11	6	25	15	11	9	3	4	4	12	9
4....	28	14	25	29	13	14	11	8	13	6	16	16
5....	7	16	17	7	10	12	9	8	12	14	19	9
6a...	4	0	0	2	5	2	2	1	0	1	1	3
6b...	4	3	0	7	2	5	2	1	3	1	0	0
6c....	3	1	1	12	0	12	4	2	2	4	3	3
6d...	12	0	1	0	1	6	2	2	0	1	5	1
7....	3	2	8	5	3	9	2	4	6	1	7	5
8....	1	4	3	7	6	6	4	4	5	2	6	4

LINK-AIR

	Instructor A						Instructor B					
Subject No.	1	2	3	4	5	6	7	8	9	10	11	12
Exercise 1....	0	0	0	0	0	0	0	0	1	0	1	0
2....	5	6	6	6	6	6	4	4	5	24	14	4
3....	5	4	11	6	8	3	9	11	7	16	10	4
4....	6	8	4	6	10	8	24	8	3	9	9	9
5....	2	4	2	0	10	1	9	10	4	16	13	5
6a...	3	4	15	5	13	13	4	8	10	11	9	1
6b...	2	4	5	3	11	2	3	2	1	2	1	6
6c....	10	12	19	8	4	11	6	7	11	17	13	7
6d...	4	3	2	3	11	3	0	4	1	3	6	2
7....	1	3	0	2	4	1	6	1	3	6	4	1
8....	0	4	2	2	2	4	8	2	3	7	2	4
	Instructor C						Instructor D					
Subject No.	13	14	15	16	17	18	19	20	21	22	23	24
Exercise 1....	0	0	1	1	0	0	0	0	0	1	1	0
2....	2	4	2	10	16	3	0	0	7	1	1	1
3....	14	9	5	6	9	14	5	3	9	2	7	3
4....	14	7	16	13	48	18	3	3	2	1	16	14
5....	2	1	7	14	4	3	2	2	8	6	5	11
6a...	6	7	5	12	1	7	7	1	4	7	13	2
6b...	3	3	2	1	4	3	3	1	3	2	10	2
6c....	8	6	9	12	24	9	2	9	9	7	6	4
6d...	1	2	1	2	4	8	0	3	2	1	3	0
7....	1	0	1	7	0	1	0	0	2	0	3	0
8....	1	1	2	1	0	1	5	1	5	1	3	6

CONTROL-AIR

	Instructor A						Instructor B					
Subject No.	25	26	27	28	29	30	31	32	33	34	35	36
Exercise 1....	1	0	0	0	2	1	0	0	0	1	0	1
2....	9	6	6	4	8	9	4	9	8	4	7	8
3....	14	8	8	6	10	8	9	3	5	10	5	13
4....	5	4	5	12	4	8	18	3	20	5	5	15
5....	1	4	5	8	6	4	3	6	5	10	4	10
6a...	15	6	3	4	8	10	7	3	9	7	7	9
6b...	2	5	3	4	0	2	3	2	5	5	8	6
6c....	22	7	12	13	12	14	23	11	26	17	15	10
6d...	7	3	7	2	8	11	0	2	0	3	0	2
7....	1	0	2	0	2	1	2	2	2	4	2	3
8....	1	4	3	3	2	4	4	4	7	5	2	2

	Instructor C						Instructor D					
Subject No.	37	38	39	40	41	42	43	44	45	46	47	48
Exercise 1....	1	1	5	1	0	0	0	1	1	0	1	1
2....	5	8	3	8	5	13	1	10	8	4	5	0
3....	5	14	14	12	10	14	7	10	7	8	2	3
4....	8	31	30	18	17	37	4	8	11	10	8	14
5....	5	16	6	12	8	7	8	12	12	15	5	5
6a...	13	14	12	16	12	8	5	10	11	7	11	14
6b...	13	2	11	3	14	4	5	4	8	1	6	9
6c....	12	16	7	8	11	4	3	20	15	11	8	6
6d...	2	3	2	5	6	2	0	2	1	0	0	3
7....	4	4	5	6	3	2	7	4	4	1	5	3
8....	3	9	3	4	4	6	5	6	10	7	8	4